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AN EXPERIMENTAL STUDY OF FLY ASH CONCRETE WITH STEEL FIBER HOOKED ENDS TO OBTAIN STRENGTH OF M30 GRADE

Samarul Huda
Student, M. Tech, Construction Technology and Management,
Department of Civil Engineering, Integral University, Lucknow, India

Anwar Ahmad
Associate Professor, (Department of Civil Engineering,
Integral University), Lucknow, India

Syed Aqeel ahmad
Associate Professor, Department of Civil Engineering,
Integral University), Lucknow, India

Zishan Raza Khan
Associate Professor, Department of Civil Engineering,
Integral University, Lucknow, India

ABSTRACT

This paper discussed an experimental study of M30 Grade of concrete using fly ash, steel fiber, cement, coarse aggregate and fine aggregate. Aim of the experimental work was to achieve a proportion of ingredients and obtain strength of M30Grade. To achieve this aim experiments were designed to vary the content of fly ash and steel fiber in cement and other ingredients (fine aggregate and coarse aggregate). The moulds were prepared using coarse aggregate, fine aggregate and the quantity of cement was gradually reduced by adding fly ash and amount of steel fiber was also varied. Two sets of fly ash were varied from 10% to 30% in step to 10% keeping the steel fiber content fixed. In the other set the amount of steel fiber was varied from 0.5% to 2% in step of 0.5% keeping the other parameter fixed. A number of combinations were tried, molded, cured as per prescribed norms and tested as per prescribed norms ((IS Code 456-2000). It was observed that 6.3 kg of cement, 15 kg of fine aggregate, 24.6 kg of coarse aggregate, 0.486 kg of steel fiber, 2.7 kg of fly ash produces the desired strength of M30 Grade of concrete. It is expected that practicing engineer will find this combination to be suitable and use it to construct building with a low cost.

Key words: *Concrete, steel fiber, fly ash and compressive strength.*

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1. INTRODUCTION

Concrete is a composite material containing hydraulic cement, water, coarse aggregate and fine aggregate. The resulting material is a stone like structure which is formed by the chemical reaction of the cement and water. This stone like material is a brittle material which gives a very high compressive strength but has very little tensile strength (Sooraj et al. 2016).Concrete is very strong in compression but weak in tension, the tensile strength of concrete is less due to widening of micro cracks existing in concrete subjected to tensile stress (Sabeena et al. 2016). Due to this, steel fiber is generally taken as a solution to develop concrete in view of enhancing its flexural and tensile strength. Fly ash is a waste product from thermal power plants (Rafat et al. 2013). The disposal of fly ash is one of major issue for environmentalists, as dumping of fly ash causes severe environmental problem (Nawaz et al. 2013). Utilization of fly ash as low cost material in concrete, instead of dumping it as waste material, and have great commercial and environmental benefits (Anita et al. 2016). It can be used particularly in mass concrete applications where main emphasis is to control the thermal expansion due to heat of hydration of cement paste (Edwin et al. 1950). It also helps in reducing thermal and shrinkage cracking of concrete at early stages (Sabeena et al. 2016). The replacement of cement with fly ash in concrete also helps to conserve energy (Nawaz et al. 2013).The inherent weakness in the concrete is to crack under small loads, at the tensile end and gradual propagation of cracks to the compression end of the member is taken care by addition of steel fiber.

Steel Fiber Fly Ash Concrete (SFFAC) is mixture of cement concrete laced with uniformly dispersed and randomly oriented suitable fibrous material. This is done to increases its structural integrity. The amount of steel fiber added to concrete mix is measured as percentages of the total weight of composites. The composites matrix that is obtained by combining cement, fly ash, aggregates and steel fibers is known as “Steel fiber with fly ash concrete”. The fiber in the cement fly ash based matrix acts as cracks arresters, which restrict the growth of micro cracks and prevent these from enlarging under load (Sabeena et al. 2016. This type of mixture is not only reliable as well as it is economical.

2. MATERIALS AND METHODS

2.1. Cement

The cement used in this experimental work is 43 Grades Ordinary Portland cement. All properties of cement are tested by referring IS 12269-1987 specification for 43 Grade Ordinary Portland cement is as under (Table 1& 2).

Table 1 Properties of Cement (Shaswata et al. 2012)

Property	Value
Specific Gravity	3.15
Initial Setting Time	90
Final Setting Time	180

Table 2 Typical chemical properties of cement (OPC-43 Grade) (Shaswata et al. 2012)

Particulars	Typical range
Lime saturation factor (LSF)	0.88-0.90
Alumina to that of iron oxide ratio	1.40-1.60
In soluble residue (% by mass)	1.20-1.60
Magnesium oxide (% by mass)	2.50-3.20
SulphuricAnhydride (% by mass)	1.60-1.80
Total loss on Ignition (% by mass)	1.20-1.60
Total Chloride (% by mass)	0.010-0.014

2.2. Fine Aggregate

Locally available sand passed through 4.75 mm IS sieve was used. Fine aggregate of Specific gravity 2.84 and fineness modulus of 3.895 were used [IS Code 383-1970].

2. 3. Coarse Aggregate

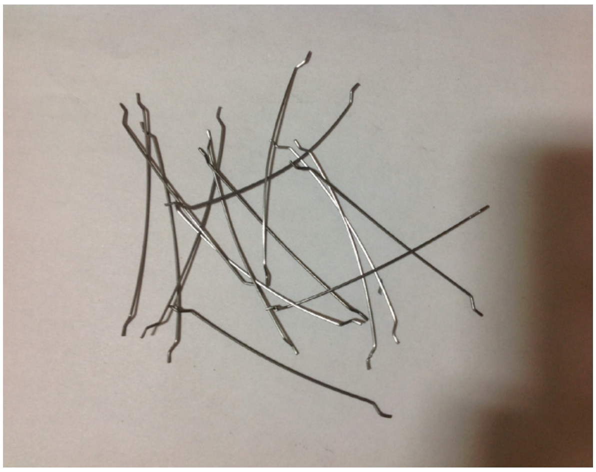
The coarse aggregates available from local sources were used with a maximum size of 20mm having the specific gravity value of 2.958 and fineness modulus of 7.136 were used as coarse aggregate [IS Code 383-1970].Coarse aggregates available from local sources was used with a maximum size of 10mm having the specific gravity value of 3.016 and fineness modulus of 5.829 were used as coarse aggregate [IS Code 383-1970].

2.4. Water

Potable water used for prepare the mixture.

2.5. Steel fiber

Steel Fiber with hooked ends of high-quality low carbon steel wire, with the characteristics of the high tensile strength, good toughness, and low price was used for concrete strengthening. The content of steel fiber was varied from 0.5% steel fibers to 2% are used in the total volume of concrete. The length of dividing steel fiber was 50 mm and the diameter of steel fiber was 0.7mm (Figure 1).



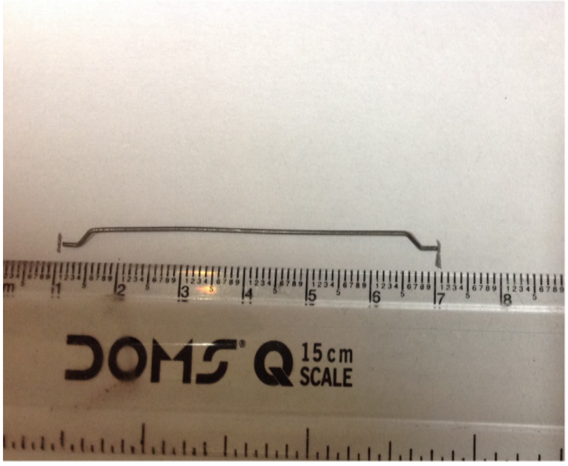


Figure 1 Steel fiber (Aspect Ratio = 60)

2.6. Fly ash

Fly ash also known as flue-ash is one of the residues generated in combustion of coal and comprises the fine particles that rise with the flue gases. Ash which does not rise is termed bottom ash. Fly ash usually refers to ash produced during combustion of coal. Fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys of coal-fired power plants and together with bottom ash removed from the bottom of the furnace is in this case jointly known as coal ash. The chemical properties are shown in Table 3 and the Fly ash mixed with cement in Figure 2.

Table 3 Chemical properties of fly ash F - Grade

Properties	Fly Ash (Class F)
Silicon dioxide, aluminum oxide , iron oxide (SiO_2 +Al_2O_3 +Fe_2O_3),min,%	70.0
Sulphur trioxide (SO_3), max,%	5.0
Moisture Content, max,%	3.0
Loss on ignition, max%	6.0

Figure 2 Fly ash mixed with cement

2.7. Mix Proportion

Mix design is known as the selection of mix ingredients and the proportion required in a concrete mix. In the present study the mix was prepared as per guidelines provided in IS code 456-2000. The mix design takes care of the amount of cement, fine aggregate and coarse aggregate in addition to other related parameters depending on the properties of constituent material. The mixture thus obtain was cast in the mould and the mould was provide with a serial no and date (during experiment and taken as control group cast).In subsequent mixture quantity of fly ash percentage was varied from 10% to 30% in steps of 10%. This way 6 samples were cast for each percentage of fly ash in the mixture (10%, 20%,30%) keeping the other parameter such as cement, fine aggregate, coarse aggregate and steel fiber.

The proportions for normal mix of M30 (1:1.7:2.6). Normal Mix was prepared as per IS Code 456-2000:

Table 4 Mixproportion

Grade	Cement	Fine aggregate	Coarse aggregate.	W/C ratio
M30	425.73kg	663.4kg	1151.4kg	0.45

2.8. Test Specimen

Cubes of size (150x150x150) mm^3were prepared using the standard modulus. The samples ware casted using the standard moulds. The samples ware casted using different percentages of fly ash (0%, 10%, 20%&30%).

In the second set of experiments the content of steel fiber was varied from (0.5%, 1%, 1.5%& 2%), keeping other parameters constant. The samples were demolded after 24 hours from casting. Cubes ware kept in tank filled with water for 7, 21& 28 days. Total specimens of 234 cubes were casted for testing the properties such as compressive strength. The details of the specimens and their notation are given below in table 5.

Table 5 List of specimens

S. No.	Notation	Cubes
1	C1 (Control mix)	18
2	C2(10% fly ash)	72
3	C3(20% fly ash)	72
4	C4(30%fly ash)	72

2.9. Compressive strength test.

For compressive strength test, for the cubes of dimensions 150 x 150 x 150 mm casted and cured as described earlier, were tested on digital compression testing machine as per I.S. 516-1959. The failure load was noted for all the six samples in a particular category and their average value has been reported to be 27.45 Mpa. The

The compressive strength was calculated as follows:

Compressive strength (Mpa) = Failure load /cross sectional area. (1)

2.10. Workability Test

Workability test was carried out by conducting the slump test and compaction factor test as per I.S. 1199-1959 on ordinary concrete and fiber reinforced concrete (Figure 3).

Figure 3 Showing slump test and compaction test

3. RESULTS AND DISCUSSIONS

The results and discussions of different tests conducted are presented in the following.

3.1. Rheology of Concrete

Fresh Concrete is a freshly mixed material which can be molded into any shape. The relative quantities of cement, aggregate and water mixed together control the properties of concrete in the wet state as well as in hardened state.

3.2. Measurement

Tests adopted for measurement in the present investigation is compressive strength. Compressive tests were conducted on cube, beam & cylinder samples in accordance with the specification of Bureau of Indian Standards. The test results are given in Table 6.

Table 6 Compressive Strength of cubic samples

S.No.	% Fly ash	% Steel fiber	7 days (Mpa)	21 days (Mpa)	28 days (Mpa)
1	0	0	31.76	38.66	42.51
2	0	0.5	27.43	33.57	40.39
		1	31.63	39.42	42.35
		1.5	30.20	37.06	40.73
		2	28.45	34.66	38.07
3	10	0.5	25.63	40.2	40.2
		1	30.90	43.8	44.76
		1.5	29.90	39.7	39.5
		2	26.66	33.25	39.86
4	20	0.5	22.07	31.67	33.09
		1	30.45	40.41	41.36
		1.5	26.86	36.73	40.86
		2	25.03	30.9	37.13
5	30	0.5	23.30	35.6	36.7
		1	25.80	37.03	40.2
		1.5	24.20	29.2	35.6
		2	21.60	28.23	33.09

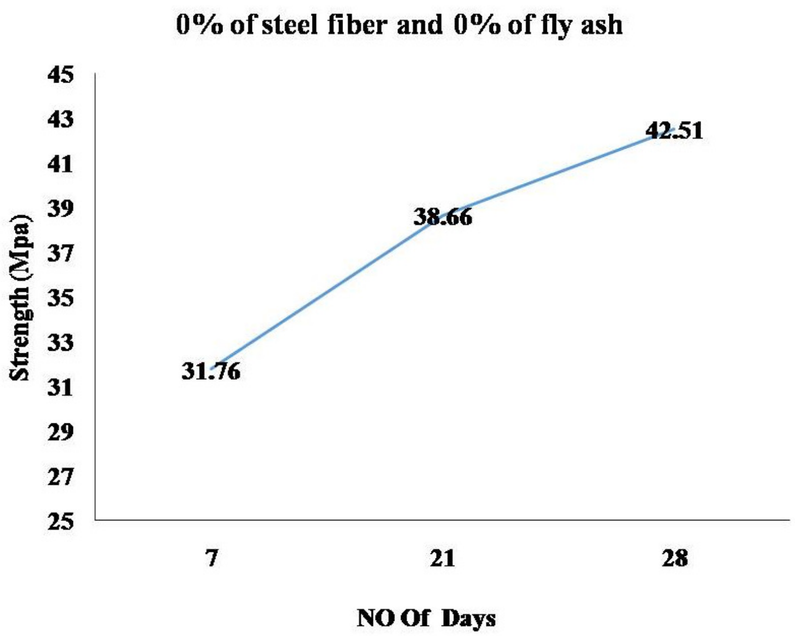


Figure 3 The graph showing the control taking 0 % of steel fiber and 0 % of fly ash

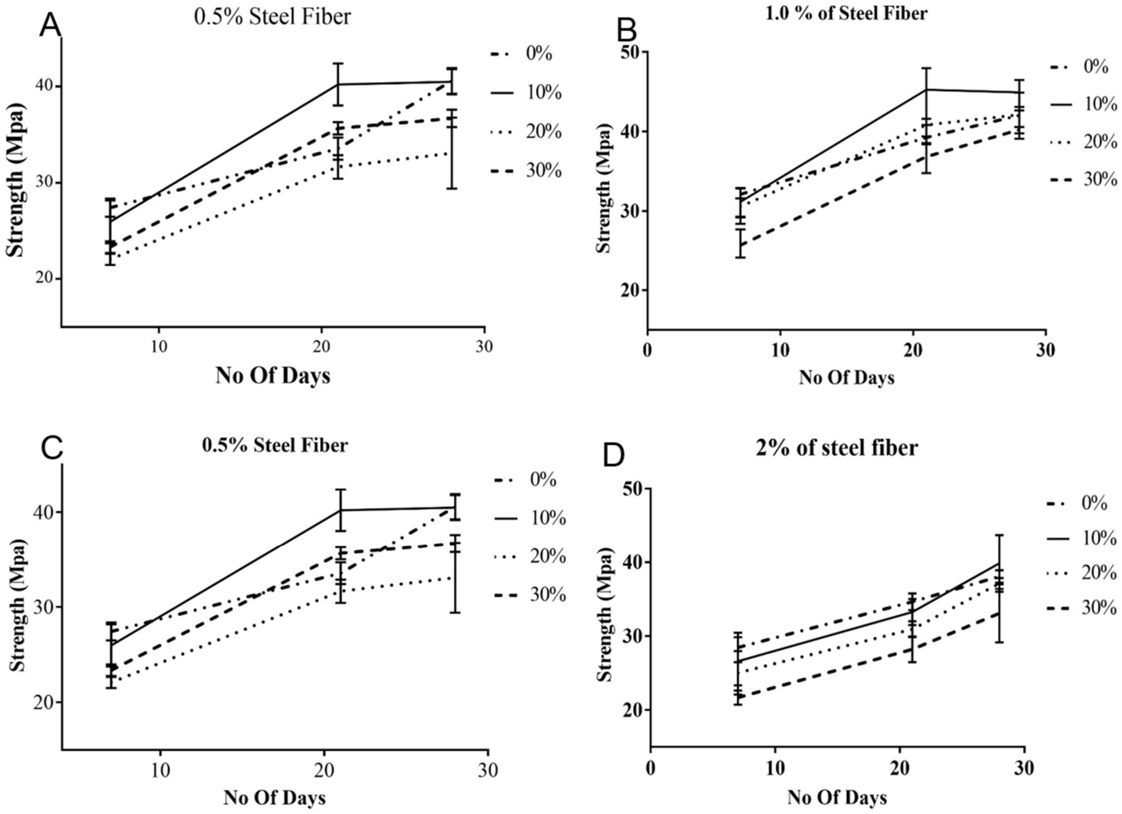


Figure 4 Variation of different amount of steel fiber with respect to fly ash for the compressive strength.

After performing the above test the target mean strength was achieved by38.28 Mpa replacing the different amount of cement with fly ash. by 10%,20%and30%. replacing the cement by 30%, on adding the fly ash 30% and 1% of steel fiber. then we are getting result when mixing 1% of steel fiber by replacing 10% of fly ash with cement .But as economical point of view we should have to use mix with 1% of steel fiber and replacement 30%of cement and adding 30% fly ash achieved the target mean strength.

By making a mixture of M30 grade in this mixture, we are replacing cement with fly ash by 10%, 20%, 30% of cement and adding steel fiber in it at 0.5%,1%,1.5% and 2% to increase the strength of the mixture . Now we have a mould size (150 x150x150) mm^3.mixture of M30 grade of concrete i.e. cement, sand, course aggregate, fine aggregate, fly ash and steel fiber. Now we have cube ready for 7 day, 21 days, 28 days after curing. Now we have to test it on universal testing machine (UTM).

So we have calculated strength of cube on different days and we are also achieving same target mean strength by mixing 1% of steel fiber and replacing the cement by 10% of fly ash and 1% of steel fiber and 30 % of fly ash by using this method .And we can also achieving the same target mean strength.

From Table 5 shows variation of Compressive Strength after 7 days, 21 days and 28 days of curing. It is found that with the increase in fiber content up to 1%, the strength is increasing i.e Compressive Strength is found to be higher at 1% fiber content and with further increase in fiber content the strength is decreasing.

5. CONCLUSIONS

Replacement of cement by fly ash (10%) and addition of 1% steel fibers result in higher compressive strength further addition of more than 1% steel fibers will bring down the compressive strength. Addition of 1% steel fibers result in higher tensile strength and use of more than 1% steel fibers will bring down the compressive strength. Based on the compressive strength and tensile strength it can be concluded that the optimum percentage of steel fiber to be added in the concrete mix is 1% by volume fraction.

REFERENCES

[1] IS 383:1970, Specification for coarse and fine aggregates from natural sources for concrete (second revision), Bureau of Indian standards, New Delhi, India.

[2] Ilker BekirTopcu, M. Canbaz (2007), Effect of different fibers on the mechanical properties of concrete containing fly ash Construction and Building Materials 21, 1486–1491.

[3] Chih-Ta Tsai, Lung-Sheng Li, Chien-Chih Chang, Chao-Lung Hwang (2009), Durability Design and Application of Steel Fiber Reinforced Concrete in Taiwan, the Arabian Journal for Science and Engineering, Volume 34, Number 1B.

[4] IS Code: 10262-2009, Recommended guidelines for Concrete mix design, Bureau of Indian Standards, New Delhi, India

[5] IS: 516-1959, Indian standard methods of tests for strength of concrete, Bureau of Indian Standards, New Delhi, India.

[6] B. Krishna Rao, V. Ravindra (2010), Steel Fiber Reinforced Self compacting Concrete Incorporating Class F Fly Ash, International Journal of Engineering Science and Technology Vol. 2(9),4936-4943.

[7] Falah A. Almottiri (2011), Physical Properties of Steel Fiber Reinforced Cement Composites Made with Fly Ash, Jordan Journal of Civil Engineering, 5(2).

[8] Osman Gencel, Witold Brostow, Tea Datashvili and Michael Thedford (2011), Workability and Mechanical Performance of Steel Fiber-Reinforced Self-Compacting Concrete with Fly Ash, Composite Interfaces 18,169–184.

[9] Falah M. Wegian, Anwar A.Alanki, Hana M. Alsaeid, Fahad A. Alotaibi (2011), Influence of Fly Ash on Behavior of Fiber Reinforced Concrete Structures, Journal of Applied Sciences,11(17):3185-3191.

[10] Vikrant S. Vairagade and Kavita S. Kene, Introduction to Steel Fiber Reinforced Concrete on Engineering Performance of Concrete, 2012, *International Journal of Scientific & Technology Research*, 1(4), ISSN 2277-8616

[11] Vasudev R and Dr. B G Vishnuram, Studies on Steel Fibre Reinforced Concrete – A Sustainable Approach, 2013, *International Journal of Scientific & Engineering Research*, Volume 4, Issue 5, 1941 ISSN 2229-5518

[12] MohdMuzammil Ahmed and Mohd Majiduddin, Flexural Behaviour of Ternary Blended Steel Fibre Reinforced Concrete Beams Using Crimped Fibres, 2015 *International Journal of Engineering Sciences &Research Technology* ISSN: 2277-9655

[13] Sooraj Chandra R.S and Dr.Sabeena M.V Experimental and Analytical approach to Study the Effect of Tension Stiffening and Cracking in Fibre Reinforced Concrete"2016 International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organization)

[14] RafatSiddique. Properties of concrete incorporating high volumes of class F fly ash and san fibers, 2003 scince direct cement and concrete research.

[15] Nawaz, Disposal and Utilization of Fly Ash to Protect the Environment, 2013International Journal of Innovative Research in Science, Engineering and Technology.

[16] Anita Bhatia S.S.and Jain Subodh P.G, Greener concrete using coal industrial waste (fly ash): an efficient, cost effective and eco-friendly construction materials for the future, 2016 Journal of Science and Technology Advances J Sci Tech Adv. Vol. 1 (Issue 1): 8-14.

[17] Bibha Kumari and Vikas Srivastava, Effect of Waste Plastic and Fly Ash on Mechanical Properties of Rigid Pavement. International Journal of Civil Engineering and Technology, 7(5), 2016, pp.247–256.

[18] M. Keerthi and K. Prasanthi, Experimental Study On Coir Fibre Reinforced Fly Ash Based Geopolymer Concrete For 10m. International Journal of Civil Engineering and Technology, 8(1), 2017, pp. 464–472.

[19] Jeevanantham V., Jayashree J and Magudeaswaran P., Influence of Fly Ash in Strength Characteristics of Cohesive Soils. International Journal of Civil Engineering and Technology, 7(6), 2016, pp.67 – 72. Edwin S.and Newman A, Study of the Determination of the Heat of Hydration of Portland Cement, 1950 Journal of Research of the Nationa l Burea u of Standards Vol. 45, No.5.

[20] Shaswata Mukherjee, Saroj Mandal and Adhikari. U.B, Study on the physical and mechanical property of ordinary portland cement and fly ash paste, 2012 International Journal of Civil and Structural Engineering Volume 2, No 3.